

**Review of the US Antarctic Marine Living Resources Program (US AMLR),
Antarctic Ecosystem Research Division (AERD), Southwest Fisheries Science
Center**

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Marc Mangel (Chair), Eileen Hofmann, Denzil Miller, Polly Penhale, Phil Trathan*

*Marc Mangel is Distinguished Professor of Mathematical Biology, Director of the Center for Stock Assessment Research, University of California Santa Cruz and Chair of the U.K. Special Committee on Seals (msmangel@ucsc.edu)

Eileen Hofmann is a Professor of Oceanography at Old Dominion University, Chair of the Southern Ocean Global Ocean Ecosystems Dynamics Program and Vice Chair of the Scientific Committee on Antarctic Research Group of Experts on Oceanography (hofmann@ccpo.odu.edu).

Denzil Miller is Executive Secretary of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Honorary Research Professor at the University of Tasmania, and was Chair (1997-2001) of the CCAMLR Scientific Committee (denzil@ccamlr.org)

Polly Penhale is Environmental Officer, Office of Polar Programs U.S. National Science Foundation, U.S. Representative to the Committee for Environmental Protection, Antarctic Treaty, and Member, U.S. Delegation to CCAMLR (ppenhale@nsf.gov)

Phil Trathan is Head of Conservation Biology and Project Leader for Ecosystem Structure and Biodiversity, British Antarctic Survey and Member, U.K. delegation to CCAMLR (pnt@bas.ac.uk)

Executive Summary

- The U.S. Antarctic Marine Living Resources (AMLR) Program at the Southwest Fisheries Science Center, La Jolla, CA has achieved remarkable success over its approximately 25 year history. This success includes: (i) contributions as part of the U.S. Delegation to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and its Scientific Committee (SC-CAMLR), and (ii) development of an almost unique program of data collection and analysis for Ecosystem Based Fishery Management. The AMLR Program is now mature and has reached a point where its past successes, recent change in leadership, and prevailing circumstances have mandated consideration of its future. In this respect, business as usual cannot continue.

- AMLR requires a vision and strategic but flexible framework to allow prioritization of activities, scientific products, and support for U.S. Southern Ocean and Antarctic policy. This vision should be to undertake a program of scientific research on Antarctic marine living resources to improve knowledge of ecosystem dynamics and function and to provide scientific advice on Ecosystem Based Management of Antarctic ecosystems, including: (i) enhancing ecological understanding of Antarctic harvested, dependent and related species; (ii) identifying and assessing changes in these species due to human based activities, natural variability, and climate change; (iii) providing high quality scientific evidence, from an ecosystem-based perspective, to support the sustainable harvesting and precautionary management of Antarctic marine living resources, and (iv) promoting scientific excellence in the research of Antarctic marine living resources through collaboration consistent with national policy priorities and provision of scientific innovation and leadership.

- To achieve the program's strategic goals, AMLR and NMFS need to undertake actions at three time scales. Such actions are relevant to the immediate needs of the AMLR Program and to the integration of AMLR science into developing future national and international Southern Ocean programs. Over the shortest time scale (1-3 years) AMLR should among other things: (i) develop a long-term plan for sustained access to a research platform(s) for ship-based studies; (ii) make its unique datasets widely available; (iii) greatly increase the rate of peer-reviewed journal publications; (iv) initiate an integrated stock assessment framework for estimating krill abundance; and (v) continue and advance marine spatial planning. In the medium range time scale (3-5 years), among other activities, AMLR should: (i) sustain a program of graduate student and post-doctoral training; (ii) develop relationships with scientists associated with the Intergovernmental Panel on Climate Change (IPCC), for including analyses of AMLR data in Climate Change Assessment Report 5 (IPCC AR5). On the scale of 5 years and beyond AMLR should: (i) expand its staff base to include another oceanographer, a fish biologist, and a logistics coordinator, and (ii) increase engagement with the broader Southern Ocean scientific community both nationally and internationally.

- To assess progress in meeting the above goals, the next review of the AMLR Program should take place in September 2013, four years hence.

Introduction

This report represents the conclusions of the panel convened to review the U.S. Antarctic Marine Living Resources (AMLR) Program of the Antarctic Ecosystem Research Division (AERD), Southwest Fisheries Science Center. We generally use “AMLR” or “AMLR Program”, recognizing that some of our recommendations may refer to AERD and not AMLR. We regard a single report as the most efficient way to consolidate our discussions and to provide more focus to our recommendations.

Based on two intensive days of presentations and discussions, we found that the AMLR Program is at a crucial point in its development. It is now time to consolidate gains and reflect on previous accomplishments as a basis for developing a strategy for the future of the Program. Indeed, the non-availability of the previous research vessel, while a crisis, is also an opportunity to rethink and set priorities for AMLR activities.

It became very clear during the review that AMLR scientists face a wide range of tradeoffs for their time, expertise, and funding. Dealing with such tradeoffs requires prioritization and flexibility to modify Program needs and goals, as well as the ability to adjust to current circumstances and to set future directions.

We begin by assessing the AMLR Program’s current status, then continue with a strategic vision for the Program. Recommendations for action on time scales of 1-3, 3-5, and beyond 5 years are provided. We end with a brief conclusion.

Assessment of the Current Status of the AMLR Program

The 1980 Convention on the Conservation of Antarctic Marine Living Resources (CAMLR Convention), which came into force in 1982, forms part of the Antarctic Treaty System. It is implemented in the United States through the U.S. Antarctic Marine Living Resources Convention Act of 1984. The Act established a directed research program, known as the U.S. Antarctic Marine Living Resources (U.S. AMLR) Program. The Antarctic Ecosystem Research Division (AERD) of the Southwest Fisheries Science Center has managed the AMLR Program since 1990.

Scientists in the AMLR Program conduct a broad range of research activities focused on the Antarctic marine ecosystem, including a field program consisting of physical and biological oceanographic studies that incorporate research on Antarctic krill (*Euphausia superba*, henceforth simply krill, although there other species of *Euphausiids* in the Southern Ocean), krill-dependent predators, finfish and benthic invertebrates. These studies are conducted at two land-based field camps on the South Shetland Islands and on-board ship during an annual field program in the oceanic waters around the South Shetland Islands.

Modeling studies and stock assessments are also a strong component of the AMLR Program. These produce analyses and advice that form critical contributions to the wider body of scientific advice upon which the Commission (CCAMLR) set up under the

CAMLR Convention bases its management decisions. Within the broader international CCAMLR scientific community, scientists in the AMLR program have played a major leadership role in the CCAMLR Scientific Committee (SC-CAMLR), as well as in its working groups, subgroups, and scientific workshops.

A current AERD staff of eleven full-time employees plus an officer from the NOAA Corps conduct an ambitious program of scientific research, including the development of scientifically-based management advice. This work draws on a variety of established and productive collaborations with students and scientists at a wide range of national and international institutions. The responsibility for the Program's funding, planning and conduct rests with the AERD. The demands of logistics planning and the time required to conduct a lengthy annual (up to six months) field program consumes a major part of each annual work cycle. The time devoted to the planning and preparation of papers for SC-CAMLR and its working group's meetings also takes up a significant amount of time. Participation in several related Antarctic meetings further adds to the AMLR Program's crowded annual calendar.

The time demands outlined above, the Program's past successes and a change in its leadership and prevailing circumstances (i.e. potential loss of a sea-based research platform) have mandated consideration of its future. In this respect, and because of the accumulation of ever increasing amounts of data, the AMLR Program has reached a point where "business as usual" is no longer an option. Other contributory factors include increasing opportunities to take advantage of technological advances in data collection, as well as the emergence of critical new areas of field research and scientific analyses to which AMLR is poised to contribute (e.g., climate change, marine spatial planning).

In the past, the AMLR Program has been very successful in accruing a solid and diverse body of scientific knowledge. It has provided scientific input to the development of U.S. Antarctic Policy, which is firmly based on the conduct of science in Antarctica and the Southern Ocean. AMLR has also made unparalleled contributions to the development of a mature SC-CAMLR. However, while the AMLR Program is well known and respected within CCAMLR, it is virtually unknown in the broader scientific community. This includes not only the U.S. and international academic community, but also includes related NOAA research programs. Furthermore, the AMLR Program is generally not producing peer-reviewed papers that reach the non-polar community and participation in non-polar scientific meetings has not been a priority. Thus, opportunities for making a broader scientific and societal impact have been limited.

We are confident that the intellect and datasets exist within the AMLR Program to improve the situation outlined above and better meet the Program's goals. The 2009 Program Review therefore provided an opportunity for pause and reflection to facilitate the development of long and short-term priorities by the AMLR Program. Strategic planning and priority setting, including the *status quo*, and enhanced funding scenarios, provide the opportunity for the AMLR Program to move to the next level of excellence. We are convinced that AMLR program is uniquely poised to make this leap if it is given the needed resources and support.

Strategic Framework

We believe that the AMLR program will benefit from a concise statement clearly outlining its purpose and function. Such a statement should on the AMLR Program's overall objectives and provide a basis for developing operational goals against which outcomes. The objectives and goals should focus on the time-series and project-based elements. The strategic framework should encompass past achievements, anticipate future strategic needs and indicate that:

The primary purpose of the U.S. AMLR Program is to undertake a program of scientific research on Antarctic marine living resources to improve knowledge of ecosystem dynamics and function and to provide scientific advice on the ecosystem-based management of Antarctic ecosystems.

This research should:

- Enhance ecological understanding of Antarctic harvested, dependent and related species;
- Identify and assess changes in these species arising from human based activities, natural variability, and climate change;
- Provide high quality scientific evidence, from an ecosystem-based perspective, to support the sustainable harvesting and precautionary management of Antarctic marine living resources; and
- Promote scientific excellence in the research of Antarctic marine living resources through collaborations consistent with national policy priorities and provision of scientific innovation and leadership.

Finally, the strategic framework should provide a basis for affording priorities to AMLR-sponsored activities, taking account of a need for flexibility in responding to changing national and international priorities. Periodic review of AMLR Program results should be factored into the framework to measure the Program's operational performance with respect to its objectives and goals.

Achieving the Vision: Action over the Next 1-3 Years

There is no doubt that the AERD would benefit from a large infusion of financial support. That said, there are many things that can be done quickly, with a modest amount of new funds, by prioritizing current activities. We consider the most important priorities to be:

Develop a Long-term Plan for Sustained Ship Availability. The current lack of a suitable platform for AMLR ship-based field program underscores the vulnerability of the Program. We consider it essential that the AMLR Program, with support and guidance from NOAA NMFS and NSF Office of Polar Programs, develop a plan for

maintaining long-term sustained access to a ship(s) with adequate facilities to support the necessary at-sea measurements and projects.

Make AMLR Data Widely Available. This includes ship-based (e.g. krill net and acoustic, physical environment) and terrestrial (e.g. penguin population and life history) data. If doing this in a timely manner requires the addition of a data manager to the staff, then one should be appointed. It is essential that the data are not only accessible, but that they are widely advertised as well.

Publish in the Peer-Reviewed Ecological Literature. There is no better advertisement than peer-review publication, the primary currency of science. We consider that it is a high priority that AMLR participants publish more extensively in the general ecological literature. This includes, at the minimum, a major modeling paper on the Krill Predator Fishery Model, a major field paper on penguin ecology, and a shorter review paper (e.g. aimed for *Science* or *Trends in Ecology and Evolution*) as a demonstration of the effectiveness of the AMLR approach in the context of Ecosystem Based Fishery Management and the International Panel on Climate Change (IPCC) assessments.

Re-Evaluate the Frequency of AERD Director's Field Work. The two points above are extremely important to the AMLR Program's overall success. It will be much easier to achieve those goals if the Director does not go to the field annually during the first several years of his tenure. His time would be best spent at his AERD office guiding the AMLR team in data analysis and the production of publications, as well as focusing on his own modeling research (perhaps aided by a post-doctoral colleague) Additionally, increased interaction and collaboration with NOAA Fisheries headquarters staff will enhance the Program's effectiveness. A reduction in the Director's field time will also facilitate increased interaction with the Department of State and the National Science Foundation to result in a strengthened U.S. position at CCAMLR.

Invest in Analyzing AMLR Data. There is much that can be learned from further analysis of existing data. A National Research Council (NRC) post-doctoral position would be an ideal vehicle for training a young scientist and for analyzing existing AMLR data. Similarly the NSF provides post-doctoral opportunities that could be used to provide opportunities for young scientists to bring new ideas and approaches to such analyses.

Undertake a Strategic Determination of AMLR Needs. The identification of potential AMLR needs is an urgent priority and should include an assessment of which monitoring activities can be undertaken less frequently than on an annual basis. It is indeed possible that after sustained evaluation of current activities, AMLR scientists will conclude that all monitoring should be undertaken annually. However, this should be a well thought-through conclusion, rather than a continuation of business as usual. It is also essential that any determination of both current and future AMLR needs should be developed within a strategic framework (as above) that accounts for assigned priorities, designates deployment of personnel and outlines a timetable for the delivery of

results/outcomes. Other key aspects to be addressed should include analyses of the adequacy of logistical support (both ship and shore-based), staffing levels (including training requirements and student involvement) and the utilization of external (other than NOAA-based) funding opportunities. Formal consideration should also be given to potential future expansion of the AMLR Program in the next 3 to 5 years to account for non-krill based studies and to anticipate the potential demands of climate change or other research needs. This strategic framework should identify the appropriate level of AMLR-based leadership input into the CCAMLR scientific realm as well as the building of scientific ties with other relevant research institutions, or individuals, at a national and international level. It should also be flexible enough to anticipate priority needs as these emerge.

Initiate the Integrated Assessment for Providing Management Advice for the Antarctic Krill Fishery. Increasing national and international logistic and resource constraints mean that stock assessments for Antarctic krill such as provided by the CCAMLR 2000 Synoptic Survey will be increasingly difficult to generate. However, AMLR is well poised to lead future stock assessments that make better use of the mesoscale monitoring surveys undertaken by AMLR, the British Antarctic Survey (BAS) and the Palmer Station Long Term Ecological Research (PAL LTER) Programs. Incorporating information from krill predators, the fishery, and environmental data will be essential if these mesoscale surveys are to provide useful demographic information about krill. Therefore, AMLR should enhance its collaborative links with other groups, in particular BAS and PAL LTER but also colleagues from krill harvesting nations, to develop an integrated krill stock assessment. An integrated assessment would have the added advantage of facilitating estimation of both absolute and proportional krill recruitment, which will be an enormous step forward for SC-CAMLR and CCAMLR's management of the krill resource.

Work with NSF Polar Programs, the Palmer Long-term Ecological Research Program, British Antarctic Survey & AMLR Monitoring Programs to Plan a Joint Workshop . By integrating the work done by the PAL LTER, BAS, and AMLR along the Antarctic Peninsula, each group will develop a much more comprehensive understanding of this extremely important part of the Antarctic and will help integrate AMLR into the broader Antarctic scientific community.

Continue the Development of Marine Spatial Planning. Marine spatial planning is a high priority for CCAMLR, the overall Antarctic Treaty System and the broader marine management community. The extensive, high-quality AMLR datasets and models form an important resource for developments in this area. The most effective contributions within the CCAMLR forum will be through partnerships between the AMLR and other researchers, particularly with scientists supported by the BAS and the NSF conducting long-term research programs in the Antarctic Peninsula region. Additionally, collaboration with the NSF Office of Polar Programs, with respect to its activities directed to environmental stewardship in Antarctica, would enhance success in this area of activity.

Provide a Program of Professional Development for the AERD Director. The new Director of the AERD, Dr. George Watters, has taken on a range of new and challenging responsibilities. Formal professional development in scientific and research management will allow him to function more efficiently, both in AMLR and the wider NMFS community.

Achieving the Vision: Action over the Next 3-5 Years

On a slightly longer time scale and with a moderate amount of additional funding, we believe the following actions are critical:

Undertake Analysis of Core Data Holdings to Develop a Regional Study for the Intergovernmental Panel on Climate Change Assessment Report 5. The Program's integrated data holdings range from oceanography, phytoplankton, krill, and fish to air breathing predators. They are likely to provide an opportunity for high profile, time-integrated analyses with high citation potential and which will contribute significantly to raising the AMLR Program's profile. Key analyses should be completed in time for March 2011, and published before August 2012 in order to fit with the IPCC timetable.

Expand Beyond Krill-based Studies. The current species-centric approach within AMLR is based on the original goals and objectives of CCAMLR. However, with the recognition of the importance of climate change effects on Antarctic ecosystems, it is important that AMLR begin discussions of how to be more inclusive of such effects in sampling marine ecosystem components. Some effort has been made to collect data on ancillary species such as flighted seabirds and other zooplankton taxa. These types of measurements should be expanded so that AMLR will be in a position to benchmark and detect changes in the ecosystem as well as to interface with programs that are focused on climate change.

Sustain a Graduate Student and Postdoctoral Program. The NRC and/or NSF postdoctoral positions described above should be viewed as the first in a continuous series of postdoctoral colleagues and graduate students working with AMLR staff. In addition to training the next generation of Antarctic scientists, post-doctoral colleagues and graduate students will help the Program attain the visibility it deserves.

Add a Staff Position for the Organization and Training of Observers. All indications are that the need for observers on fishing, commercial, support and tourist vessels in the Southern Ocean is poised to increase greatly. An AERD staff member dedicated to such training and logistics will also be able to support other logistical aspects of the AMLR Program.

Add a Staff Position for a Physical Oceanographer. The AMLR Program has collected extensive hydrographic data sets, most of which remain unanalyzed, in part because of the workload of the single oceanographer on staff. Another staff member trained in modern physical oceanography (including use of circulation models) will help

move the AMLR program's hydrographic data collection activities to science-based interpretations integrating oceanographic data into ecological studies.

Achieving the Vision: Action Beyond 5 Years

On the longest time scale, and with the greatest possibility of increased funding, we consider these actions to be critical:

Add a Staff Member to Work on Abundance and Diet of Pelagic Fish. This work will feed into a more precise formulation of the Integrated Assessment Framework for krill, as well as other species. For example, AMLR has contributed to the dataset on myctophid fish that resides with CCAMLR but which has not been fully analyzed.

Sustain Increased Engagement with Broader Southern Ocean Scientific Community. A number of ongoing initiatives involve planning activities and programs with time frames of ten to fifty years. These will provide the basis for much of the scientific direction for future Southern Ocean research. Such initiatives include the Southern Ocean Observing System (SOOS), the Integrating Climate and Ecosystem Dynamics (ICED) program, and the Southern Ocean Sentinel (SOS), all now currently under development. All three international programs have scientific goals and objectives that are directly relevant to those of AMLR.

Participation in the SOOS will enhance the AMLR science program. For example, the SOOS has an objective of developing automated sensor systems for the Southern Ocean. Involvement in designing the SOOS might allow some of AMLR's monitoring measurements to be moved to other groups and/or to automated sensor systems (e.g. for chlorophyll). Involvement in how the SOOS is designed is critical to ensuring that coverage occurs in areas of interest to AMLR.

Furthermore, contribution of the AMLR measurements to the larger SOOS data management system will allow access to these data by a wider community. In this way, the AMLR data will become critical to the wider scientific community (beyond CCAMLR), which will provide international support for funding long-term acquisition of relevant data.

The initial focus of the ICED program (next 3-5 years) is on developing models to be used to understand the effects of climate and exploitation on Southern Ocean food webs. The development of a community that will use such models is an ICED priority. The AMLR Program possesses data sets and scientific insights that could be integral to model development. The AMLR Program would in turn benefit from working with the ICED modeling community as this will provide a framework for broader synthesis and integration of AMLR data and ideas.

The focus of the SOS in the next 3-5 years is on developing assessments of the state of understanding of climate impacts on Southern Ocean ecosystems. The AMLR program should aim to provide information that can be used in the IPCC AR5. The AMLR

Program is in a unique position to provide major input into the SOS assessments. Its long-term data sets are globally unique and could provide the basis for much of the assessment developed by SOS. The SOS is designed as a 30-50 year program and as such could provide a framework for integrating AMLR data into a larger, long-term circumpolar program.

Involvement in the scientific programs beyond those that are focused on the Southern Ocean is important for AMLR as scientific focus shifts to Earth-system issues. The Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) Program of the International Geosphere-Biosphere Program (IGBP) is focused on understanding the sensitivity of marine biogeochemical cycles and ecosystems to global change at long time scales. Participation by AMLR scientists in IMBER-related working groups, focus groups, and workshops would raise the visibility of AMLR and also allow AMLR data and results to be placed in a larger context. Involvement in IMBER follow-on programs will also ensure an AMLR international science legacy outside CCAMLR.

The AMLR program therefore can have an important role in SOOS, ICED, SOS, IMBER and other programs to be developed in the future. To ensure this role, AMLR scientists will need to be involved in the workshops, science steering committees, and working groups tasked with developing and coordinating such programs. This will require that AMLR scientists (i) produce primary publications that result in the wider global community recognizing the value of the Program; (ii) be given the time, support and flexibility to participate at influential levels in international programs (other than, but still including CCAMLR), and (iii) expand AMLR to include the expertise and personnel (e.g. climate and food webs analyses, sensor systems) to effectively interact with these programs. To avoid over-commitment of already busy staff, careful consideration needs to be given to an evolving, strategic approach to involvement in such programs as well as to the priority to be attached to such involvement.

Conclusion

Science is the focus of U.S. activity in the Antarctic and the AMLR Program is a crown jewel of Antarctic science. The research conducted by AMLR is a unique integration of an interdisciplinary approach that serves as a model for NMFS colleagues working in other ecosystems. Indeed, the AMLR program is a model of how to conduct scientific research in support of Ecosystem Based Fishery Management. It therefore should be made more widely known both within and outside the NMFS.

AMLR has considerable potential to take new, innovative and important steps forward. Now is therefore the time to consolidate gains and to begin developing approaches and strategies so that AMLR scientists will be poised to assume leadership roles in programs defining the future of Southern Ocean research.